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SECOND SEMIANNUAL (TYPE II) PROGRESS REPORT FOR NASA
OHIO-ERTS DATA USER PROGRAM (JANUARY-JUNE, 1973)

Project Title: Relevance of ERTS-1 to the State of Ohio

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Preface

The objective of this contract is to determine how state government can benefit from orbital surveys such as ERTS-1. The program is multidisciplinary and involves the experimental evaluation of ERTS-1 imagery and data relay capabilities to environmental quality, agriculture and forestry, and geographic (land-use) applications in Ohio. Initial ERTS-1 photographs are being analyzed in combination with aircraft and ground-truth photographic and radiometric data for five Ohio study sites. Participation in the DCS experiment involves the use of a single data collection platform for demonstrating the potential of satellite relays in state environmental quality monitoring networks. The statewide program involves the cooperation of the Departments of Natural Resources, Health and Public Works, Economic and Community Development (Lead Department), Transportation, the Environmental Protection Agency, and The Ohio State University. Prime technical subcontractor is the Battelle Columbus Laboratories.

During the first six months, project effort concentrated on developing an effective multiagency program for collecting, analyzing, and evaluating ERTS-1 data for Ohio while maintaining an active user awareness program. Effort during the second six-month period has emphasized on-site/ground-truth data collection and more extensive demonstration/documentation of the application candidates identified during the preliminary data analysis phase of the project. These included principally surface mining and land-use applications. In addition, initial considerations have been given to the potential utility of ERTS imagery to state Lake Erie water quality management interests and the inauguration of procedures to ascertain estimates of the benefits associated with the more significant state use possibilities. User awareness efforts continued with the major accomplishment being the completion and distribution of an Ohio-ERTS Data User Handbook.

I. INTRODUCTION

This report represents the second semiannual (Type II) report prepared under the Ohio-ERTS Data Users Contract, NAS5-21782. The report summarizes the status and progress of this program from January 1 through June 30, 1973.

Discussion is presented in the same format as used in the bimonthly progress reports and thus treats data collection, data analysis, DCS, and data utility assessment activities. In addition, a section noting significant results during this period is provided along with a miscellaneous section describing other project developments of potential sponsor interest such as press releases, significant correspondence, visits, etc. And finally, selected items prepared during this second semiannual reporting period are contained in the Appendix.

II. DATA COLLECTION

A. ERTS-1 Data

Table I correlates dates of ERTS-1 orbital traces over Ohio with the data received. As can readibly be observed, we have received imagery for only 45 days out of the 95 days that ERTS-1 has flown over Ohio since August 21, 1972. (We expect that imagery taken during the June overflights of Ohio will be received shortly.) Thus, as reported in the last semiannual report, data for approximately one-half of the ERTS-1 Ohio overflights have been received. Table II describes the coverage and quality of the ERTS-1 imagery received according to the orbital traces over Ohio. In addition to the imagery described in these tables, compatible computer tape data have been received for most of these same scenes. Currently, multispectral color composites have been requested for most of the usable ERTS scenes.

However, since we receive all imagery that contains up to 90 percent cloud cover, only about half (52 of 98) of all imagery that we receive is of useful value. Figure 1 displays the dates and areas for which usable repetitive imagery has been received and Table III shows the availability and quality

TABLE I. SUMMARY OF ERTS-1 DATA RECEIVED ON OHIO

Date	Trace 1	2	3	4	5
1972					
Aug.	21*	22	23	24	25
Sep.	8	9	10	11	12
Sep.	26	27	28	29	30
Oct.	14	15	16	17	18
Nov.	1	2	3	4	5
Nov.	19	20	21	22	23
Dec.	7	8	9	10	11
Dec.	25	26	27	28	29
1973					
Jan.	12	13	14	15	16
Jan/ Feb.	30	31	1	2	3
Feb.	17	18	19	20	21
Mar.	7	8	9	10	11
Mar.	25	26	27	28	29
Apr.	12	13	14	15	16
Apr/ May	30	1	2	3	4
May	18	19	20	21	22
Jun.	5	6	7	8	9
Jun.	23	24	25	26	27

* Underlined dates indicate dates for which data have been received as of June 30, 1973.

TABLE II. COVERAGE AND QUALITY OF ERTS-1 DATA AVAILABLE BY ORBITAL TRACE OVER OHIO

Date	Time	Area	Quality Comments*
		TRACE 1	
8/21/72	15353	Eastern Lake Erie	Very good
8/21/72	15354	Eastern Ohio and Pennsylvania	Very good
8/21/72	15361	SE Ohio and West Virginia	Very good
9/8/72	15355	NE Ohio and Pennsylvania	Very poor
9/8/72	15362	SE Ohio and 90% West Virginia	Poor
9/26/72	15361	SE Ohio and 90% West Virginia	Poor
10/14/72	15354	NE Ohio and Lake Erie	Good
10/14/72	15361	Eastern Ohio and Pennsylvania	Good
10/14/72	15363	SE Ohio and 90% West Virginia	Poor
12/7/72	15362	NE Ohio and Pennsylvania	Very poor
12/7/72	15364	Eastern Ohio	Excellent
12/7/72	15371	SE Ohio and 90% West Virginia	Poor
1/12/73	15355	NE Ohio and Pennsylvania	Good
1/12/73	15362	Eastern Ohio and Pennsylvania	Good
1/12/73	15364	SE Ohio and 90% West Virginia	Good
2/17/73	15362	NE Ohio and Pennsylvania	Excellent
2/17/73	15365	Eastern Ohio, West Virginia, & Pennsylvania	Excellent
2/17/73	15371	SE Ohio and 90% West Virginia	Good
2/17/73	15374	SE Ohio, West Virginia, & Kentucky	Very good
3/7/73	15375	SE Ohio and West Virginia	Fair
3/25/73	15375	SE Ohio and West Virginia	Fair
4/12/73	15364	NE Ohio and Western Lake Erie	Fair
5/18/73	15362	NE Ohio and Western Lake Erie	Fair
5/18/73	15365	Eastern Ohio and Pennsylvania	Fair
5/18/73	15371	SE Ohio and West Virginia	Good
5/18/73	15374	SE Ohio, West Virginia, & Kentucky	Good
		TRACE 2	
8/22/72	15405	NE Ohio, Lake Erie, and Canada	Poor
8/22/72	15412	North from Salt Fork Lake	Poor
8/22/72	15414	East of Columbus, North of boot	Poor
8/22/72	15421	South of Ohio River boot	Poor
9/9/72	15411	NE Ohio, Lake Erie, and Canada	Poor
9/9/72	15414	East of Columbus	Poor
9/9/72	15420	SE Ohio and Kentucky	Fair

* Quality relates to general cloud cover condition over area covered by satellite photography.

TABLE II. (Continued)

Date	Time	Area	Quality Comments*
		TRACE 2 (Continued)	
10/15/72	15413	NE Ohio, Lake Erie, and Canada	Very poor
10/15/72	15415	East of Columbus	Fair
10/15/72	15422	SE Ohio and Kentucky	Fair
11/20/72	15420	NE Ohio, Lake Erie, and Canada	Very poor
1/13/73	15413	NE Ohio, Lake Erie, and Cleveland	Good
1/31/73	15415	NE Ohio, Lake Erie, and Cleveland	Very good
1/31/73	15422	East of Columbus	Very good
1/31/73	15424	SE Ohio and West Virginia	Very good
1/31/73	15431	South from Ohio River boot	Good
2/18/73	15421	NE Ohio, Lake Erie, and Cleveland	Very good
2/18/73	15423	East of Columbus	Good
2/18/73	15430	SE Ohio and Kentucky	Good
2/18/73	15432	South from Ohio River boot	Fair
3/8/73	15422	NE Ohio, Lake, Erie, & Canada	Excellent
3/8/73	15424	Columbus and Eastern Ohio	Excellent
3/8/73	15431	SE Ohio	Excellent
3/8/73	15433	SE Ohio and Kentucky	Good
4/13/73	15422	NE Ohio, Lake Erie, and Canada	Good
4/13/73	15425	Columbus and Eastern Ohio	Fair
4/13/73	15431	SE Ohio	Poor
4/13/73	15434	SE Ohio and Kentucky	Very poor
		TRACE 3	
9/28/72	15465	Toledo and Detroit	Poor
11/3/72	15473	NW Ohio, Lake Erie, and Toledo	Poor
11/3/72	15480	Columbus, SW Ohio, and East Liberty	Fair
11/3/72	15482	Southern Ohio and Kentucky	Very good
11/21/72	15474	NW Ohio, Lake Erie, and Toledo	Very poor
11/21/72	15481	Columbus and SW Ohio	Very poor
11/21/72	15483	Southern Ohio and Kentucky	Very poor
12/27/72	15480	NW Ohio	Very poor
12/27/72	15482	Southern Ohio and Kentucky	Very poor
1/14/73	15481	Southern Ohio and Kentucky	Good
2/1/73	15480	NW Ohio and Lake Erie	Very poor
2/1/73	15474	NW Ohio	Very poor
2/19/73	15484	Southern Ohio and Kentucky	Fair
3/9/73	15480	NW Ohio, Lake Erie, and Canada	Very poor
3/9/73	15485	SW Ohio	Very poor
3/27/73	15481	NW Ohio, Lake Erie, and Canada	Excellent
3/27/73	15483	Columbus and Western Ohio	Excellent
3/27/73	15490	SW Ohio, Indiana, and Kentucky	Excellent

* Quality relates to general cloud cover condition over area covered by satellite photography.

TABLE II. (Continued)

Date	Time	Area	Quality Comments*
		TRACE 3 (Continued)	
4/14/73	15480	NW Ohio, Lake Erie, and Canada	Excellent
4/14/73	15483	Columbus and Western Ohio	Excellent
4/14/73	15474	SW Ohio, Indiana, and Kentucky	Excellent
5/2/73	15480	NW Ohio and Lake Erie	Very poor
5/2/73	15482	Western Ohio	Very poor
		TRACE 4	
8/24/72	15532	SW Ohio, Indiana, and Kentucky	Very poor
8/24/72	15523	Toledo and area to the West	Poor
10/17/72	15532	Western Ohio and Eastern Indiana	Poor
10/17/72	15535	SW Ohio, Indiana, and Kentucky	Very good
12/28/72	15541	SW Ohio, Indiana, and Kentucky	Very good
1/15/73	15533	Western Ohio and Eastern Indiana	Very poor
2/2/73	15532	Western Ohio and Eastern Indiana	Very poor
2/2/73	15535	SW Ohio, Indiana, and Kentucky	Very poor
3/10/73	15541	Western Ohio and Eastern Indiana	Very poor
3/10/73	15544	SW Ohio, Indiana, and Kentucky	Fair
3/28/73	15535	NW Ohio	Very poor
4/15/73	15544	SW Ohio, Indiana, and Kentucky	Poor
5/3/73	15543	Michigan, Indiana, & NW Ohio	Very poor
5/21/73	15533	Southern Michigan and NW Ohio	Good
5/21/73	15540	Western Ohio and Eastern Indiana	Very good
5/21/73	15542	SW Ohio, Indiana, and Kentucky	Very good
		TRACE 5	
8/25/72	15582	Eastern Lake Michigan to Ohio	Fair
9/30/72	15361	Eastern Lake Michigan to Ohio	Poor
11/23/72	15591	Eastern Lake Michigan to Ohio	Very poor
1/16/73	15584	Eastern Lake Michigan to Ohio	Good

* Quality relates to general cloud cover condition over area covered by satellite photography.

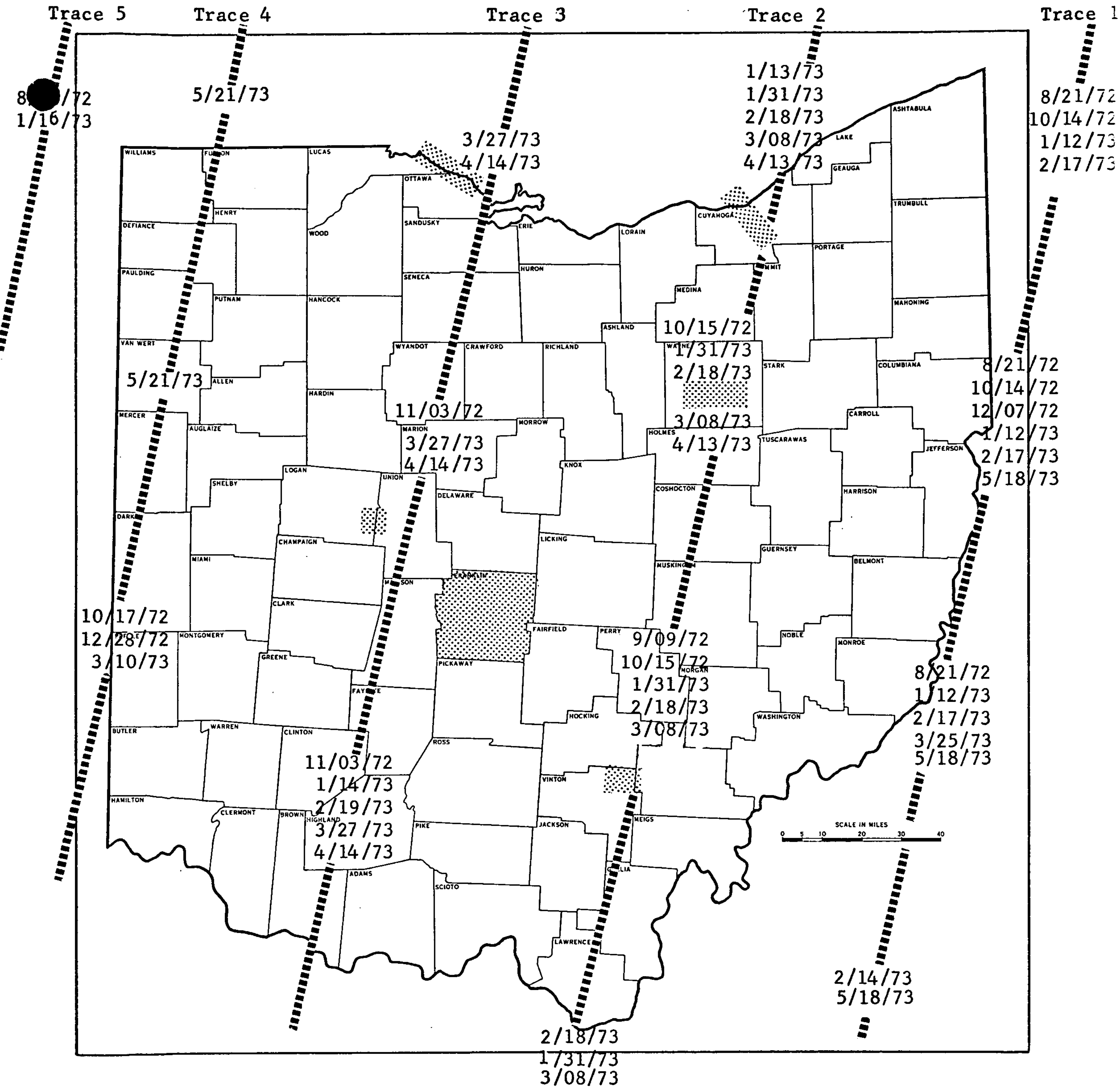

Fig. 1. Status of Usable Repetitive ERTS Imagery for Ohio.

TABLE III. STATUS AND QUALITY* OF OHIO-ERTS DATA RECEIVED BY STUDY SITE AS OF JUNE 30, 1973

Study Site	Trace	Date	Time	Quality
Cleveland and Wooster Agricultural Research and Development Center	2	8/22/72	15405	Poor
		9/9/72	15411	Poor
		10/15/72	15413	Very poor
		11/20/72	15420	Very poor
		1/13/73	15413	Good
		1/31/73	15415/ 15422	Very good
		2/18/73	15421	Very good
		3/8/73	15422	Excellent
		4/13/73	15422/ 15425	Fair
East Liberty Transportation Research Center	3	11/3/72	15480	Fair
		11/21/72	15481	Very poor
		12/27/72	15480	Very poor
		2/1/73	15474	Very poor
		3/9/73	15485	Very poor
		3/27/73	15483	Excellent
		4/14/73	15483	Excellent
		5/2/73	15482	Very poor
Ottawa	3	9/28/72	15465	Poor
		11/3/72	15473	Very good
		11/21/72	15474	Very poor
		2/1/73	15480	Very poor
		3/9/73	15480	Very poor
		3/27/73	15481	Excellent
		4/14/73	15480	Excellent
		5/2/73	15480	Very poor
Zaleski State Forest	2	8/22/72	15414	Very poor
		9/9/72	15420	Good
		10/15/72	15422	Very good
		1/31/73	15424	Very good
		2/18/73	15430	Good
		3/8/73	15431	Excellent
		4/13/73	15431	Poor

* Quality relates to cloud cover conditions over study sites.

(relative to cloud cover) of ERTS-1 imagery by study sites received to date. Moreover, it is particularly encouraging to note that imagery of good quality (cloud free) has now been received for the entire State of Ohio with the reception of the Trace 4 ERTS-1 pass of May 21 over western Ohio.

B. Aerial Photography of Ohio-ERTS Study Sites

As part of the acquisition of multispectral aerial photography of the Ohio-ERTS study sites, aircraft underflights of the East Liberty, Ottawa, Cleveland, and Wooster study sites were flown on June 14, 1973. Similar underflights had previously been conducted on August 29, 1972.

The Ohio Department of Transportation's twin-engine Beechcraft equipped with a 6" Zeiss RMK-A cartographic camera and four Battelle 70-mm Hasselblads (with 100-mm planar lens) in a multiband configuration were used to acquire the aerial photography. Also, 35-mm Ektachrome aerial shots were taken on a selective basis during the photo flights of the Ohio aircraft. The flight altitude was 12,000 feet resulting in 9-1/2" x 9-1/2" format photography at a scale of 1:24,000 and 70-mm format photography at a scale of 1:48,000.

Panchromatic film (9-1/2" x 9-1/2") was used in the state's cartographic camera. The multiband camera film and filter combinations were as follow:

Camera	Film Type (Kodak)	Filter Type (Kodak)
I	Plus X Pan	25
II	2424	89B
III	2448	Haze
IV	S0117	12

Plans are underway to conduct a third set of multispectral aerial photography of the five Ohio-ERTS study sites and other sites of interest such as surface-mining areas sometime during the next six months. The time and site decisions will be made considering such factors as areas in which timely opportunity exists, data requirements for on-going utility assessment/user awareness programs, and seasonal vegetative cover.

C. Study Site Ground Surveys

1. Photography and Radiometry

Photographic and radiometric ground-truth surveys of the five Ohio-ERTS study sites are being conducted to obtain spectral data of value in analyzing ERTS imagery. Table IV shows the current status of the ground-truth surveys by study sites. Because of delayed delivery of the ISCO strip chart recorder and calibration data for the radiometer, clouds, and, because of the sensitivity of the radiometer to temperatures below 50-60 F, spectroradiometric field work was delayed until June of this year.

Ground-truth surveys are currently being undertaken and are planned during July, August, and September of this year on days coinciding with ERTS-1 overpasses of Ohio. Table V shows the schedule of planned surveys by study sites.

The two primary sensors being utilized to obtain the ground-truth data are an ISCO spectroradiometer with recorder and 35-mm cameras with Ektachrome and infrared color film.

TABLE IV . STATUS OF OHIO-ERTS STUDY SITE GROUND-TRUTH DATA COLLECTION SURVEYS

Study Site	Air Photos Taken	Photographic and/or Radiometric Ground-Truth Surveys	Areas of Applied Interest
Cleveland	8/29/72 6/14/73	8/15/72 6/14/73 6/15/73 6/21/73 6/22/73	Water quality, Lake Erie sedimentation, shore & beach erosion, urbanized area, surface mining
East Liberty Research Transportation Research Center	8/29/72 6/14/73	8/18/72 9/14/72 6/26/73	Land use/development, agriculture, surface mining
Ottawa Wetlands	8/29/72 6/14/73	8/11/72	Wetlands mapping, flooding, agriculture, Lake Erie shore erosion, sedimentation
Wooster Agricultural Research and Development Center	8/29/72 6/14/73	9/11/72 9/27/72 6/1/73	Agriculture
Zaleski State Forest	8/29/72	8/15/72 10/14/72 10/24/72	Forestry, surface mining

TABLE V. STUDY SITE GROUND-TRUTH SURVEY SCHEDULE

Dates (1)	Sites: Cleveland	Wooster	Zaleski	Ottawa	East Liberty
Jul 11-14	X	X (2)			
Jul 29-Aug 1					X
Aug 16-19		X (2)		X (3)	
Sep 3-6			X		
Sep 21-24		X (2)			
Oct 9-12					X

(1) Coincides with ERTS passes 1-4 over Ohio.
(2) Frequency required to monitor vegetational growth of Ohio crop types.
(3) To coincide with possible algae blooms.

B

III. DCS/DCP EFFORT

The two problems cited in our first semiannual progress report were reconciled early in this second six-month period. The antenna cable rupture was was determined to have occurred in a severe wind storm and was not due to vandalism as originally suspected. Station outage from this cause terminated on January 16, 1973. A new interface device was fabricated and installed, eliminating the 60-cycle interference problem. Five meteorological sensors (for air temperature, wind direction, wind speed, rainfall, and solar radiation) were interfaced with the DCP on February 28.

Subsequently, considerable effort was expended to refurbish several water quality components of the Schneider monitoring equipment which is interfaced with the DCP. This included the removal, servicing, and replacement of the raft-mounted submersible pump, and the repair or servicing of the water quality sensors. It was found that these components, ostensibly in working order at the start of the program, had in actuality deteriorated from lack of use over an extended period. One sensor, that for water conductivity, is inoperable, but will not be replaced at present because of the relatively high cost of doing so. However, lack of a sensor for this parameter is not significant to the purpose (demonstration of ERTS relay capabilities) of the DCP installation. This refurbishing activity was completed in mid-May.

In addition the physical arrangement of the interface device was improved by providing a shelf mounting and cabled set of coaxial leads with plug-and-jack connectors. This permits the selective use of the nominally 12 (now actually 11) sensors of the equipment with the eight available channels of the DCP. Additional amplifier cards were fabricated and three water quality sensors were interfaced with the DCP in early June.

Shortly thereafter it was discovered from the NASA-provided computer printouts that the DCP, although it continued to transmit, had ceased to encode data on May 25. Investigation revealed that an electrical storm occurred in the immediate area in which the DCP is located in the interval between the last encoded and first nonencoded relays. Although there was no evidence of a direct lightning strike to the equipment, this storm apparently damaged the DCP. It was shipped to the NASA-Wallops Station on June 15 for repair and received in return on June 29. The platform was reinstalled on July 2. Subsequently, the planned interfacing of air-quality monitoring equipment will be arranged for.

In the preceding semiannual progress report the possibility of connecting the DCP to a completely mobile system was discussed. Detailed assessment of this concept resulted in the decision to make no change in the installation. The factors which influenced this decision are: (1) cost; (2) the successful overcoming of the electromagnetic interference problem; and (3) the determination that no vandalism has been or is likely to be experienced at the present site, while it would be a distinct possibility at alternate sites. This decision, however, does not negate the desirability of a mobile system.

We were unable to have a representative attend the ERTS-1 Data Collection Workshop on May 30 and 31, 1973. However, at our request, we have received from Mr. Philip T. Ryan of the NASA-Wallops Station a list of the participants and copies of those papers presented at the Workshop which were available for distribution. We look forward to receiving the proceedings when these become available.

Consideration is being given to holding a one-day workshop in mid-September to further acquaint interested potential state and other users with the DCP installation and its capabilities.

IV. DATA ANALYSIS

During the first half of the year, a special laboratory was constructed in direct response to requirements for the effective and timely acquisition and analysis of ERTS data. The laboratory's design and the type of equipment eventually installed in it were so chosen to (1) provide the most effective, in-depth research possible with state-of-the-art equipment, and (2) to provide exposure to a wide range of researchers, managers, planners, and students with varying depth of knowledge regarding remote sensing. The overriding concern in the organization of the facility was that analysis within the ERTS program be undertaken with other user/interest groups, rather than for them. The fact that over 300 researchers, planners, educators, and students visited the facility since receipt of the initial ERTS imagery on Ohio in October, 1972, and many have made repeated visits since, is indicative that these objectives are being fulfilled. Also, in response to the objective of relating to a maximum number of state user personnel so as to maximize the Ohio utility of ERTS, many analytical (problem-solving) investigations were conducted outside the original proposed study sites. A spin-off benefit of this broad application interest has been the accumulation of an extensive data base on many aspects of Ohio's natural and cultural resources.

In general, visitors to the facility were interested in the following aspects:

(1) How well does ERTS imagery provide an overall or synoptic view of an Ohio feature of interest such as Lake Erie, strip mining, metropolitan areas, etc? Here most users were interested in seeing huge land and water areas at once, having seen only portions of it on aerial photography. Usually, the interest here was in inventorying. The feature and typical viewing scales were 1:1,000,000, 1:500,000, and 1:250,000.

(2) How much detail of a given Ohio feature may be derived from ERTS data? Here the investigator requires maximum magnification for comparison with existing medium to large-scale maps, particularly at scales of 1:24,000 (the scale of the USGS topographic map sheets).

(3) How may the ERTS imagery in original, enlarged, annotated, enhanced, and color coded formats be obtained for presentations, briefings, and inclusion in reports?

(4) How long will the analysis effort take? Many times the question was posed, "How can we obtain such equipment capabilities?"

A. Data Analysis Laboratory

A discussion and a complete list of equipment contained in the data analysis laboratory are included in the first semiannual. This list includes the Spectral Data Multispectral Viewer Model 25. Delivery of the viewer had been delayed by the manufacturer by four months due to imperfections in the four 150-mm Schneider lenses. A table top model 10 had been provided by Spectral Data as a substitute for the initial analysis of ERTS data. Though plagued by some difficulties in the mechanical linkages and projection of the full image format, the Model 25 proved itself to be of considerable versatility especially when used in conjunction with the Spatial Data Image Enhancement Viewer. The viewer displays the 70-mm ERTS imagery at a fixed scale of 1:1,000,000. Color filters (three intensities of blue, green, and red) are switched in electrically. The filters are behind the condensing lens system, eliminating the need for refocusing the projection system. Neutral density filters provide the systematic reduction of transmitted light in 20 equal intervals between 0 to 100 percent transmissivity. Electrically-driven film transports move each film roll separately or ganged together, each film roll holding up to six months of film data. The need for the time-consuming mounting of 70-mm film chips is thus eliminated.

B. Equipment Modifications

Modifications within the laboratory are continuously being made to enhance the speed and effectiveness of ERTS data analysis. Among those recently made include linking of the multispectral viewer with the image enhancement viewer. This was accomplished through the addition of a second TV camera which was pointed into the screen of the multispectral viewer. This arrangement permits the individual or simultaneous display of four channels of ERTS data on the TV screen of the image enhancement viewer. The camera of the image enhancement viewer may then be used for looking at additional ERTS, airphoto, or map imagery for comparison purposes.

C. Image Transfer Techniques

During any analysis task a major concern is the ability to extract qualitative and quantative information from ERTS imagery with a given timeframe. Another major concern, however, is the ability to transfer the enlarged, enhanced, filtered, overlayed, color encoded, etc., imagery or portion thereof to a map, overlay, report, viewgraph, etc. To avoid manual drafting methods, photographic techniques have been applied to transfer information from ERTS imagery to existing thematic state maps at scales from 1:1,000,000 to 1:250,000, and topographic map sheets of 1:24,000. Selected state maps have been photographed to scale on 70-mm film and are projected as needed in conjunction with the display of corresponding ERTS imagery.

Thirty-five-mm, 70-mm, and 4" x 5" photographs are taken of 80 percent of the TV screen of the Spatial Data Density Slicing Viewer. The resulting black-and-white and color imagery is then used in transparent overlays, viewgraphs, 35-mm and 70-mm transparencies, and paper prints for reports and publications. Annotations were added on the screen or on the finished product.

This process has eliminated the need for extensive and time consuming drafting efforts of areas containing a large number of image detail. It also avoids drafting errors which occur when drawing the boundaries of any given features.

D. Data Analysis Plan

An initial data analysis plan had been included in the first semiannual status report. This plan has now been finalized and is shown in Figure 2 .

E. Data Analysis Tasks

It was initially expected that after arrival of ERTS imagery, a systematic analysis of proposed topics would be performed, and these initial results would, hopefully, evoke responses from users within participating state agencies. In reality, since the receipt of initial ERTS imagery, the analysis facility has been inundated with visitors and requests which make systematic analyses impossible. Some requests were made with anticipation that problems which could not be solved to date without great expense and effort, could be solved "the ERTS way" although most users had unrealistic estimates of time involved. Many users also did not quite realize that the purpose of the Ohio-ERTS program is to prove feasibility of numerous application candidates, and not to provide the total solution to an existing problem(s) in one area.

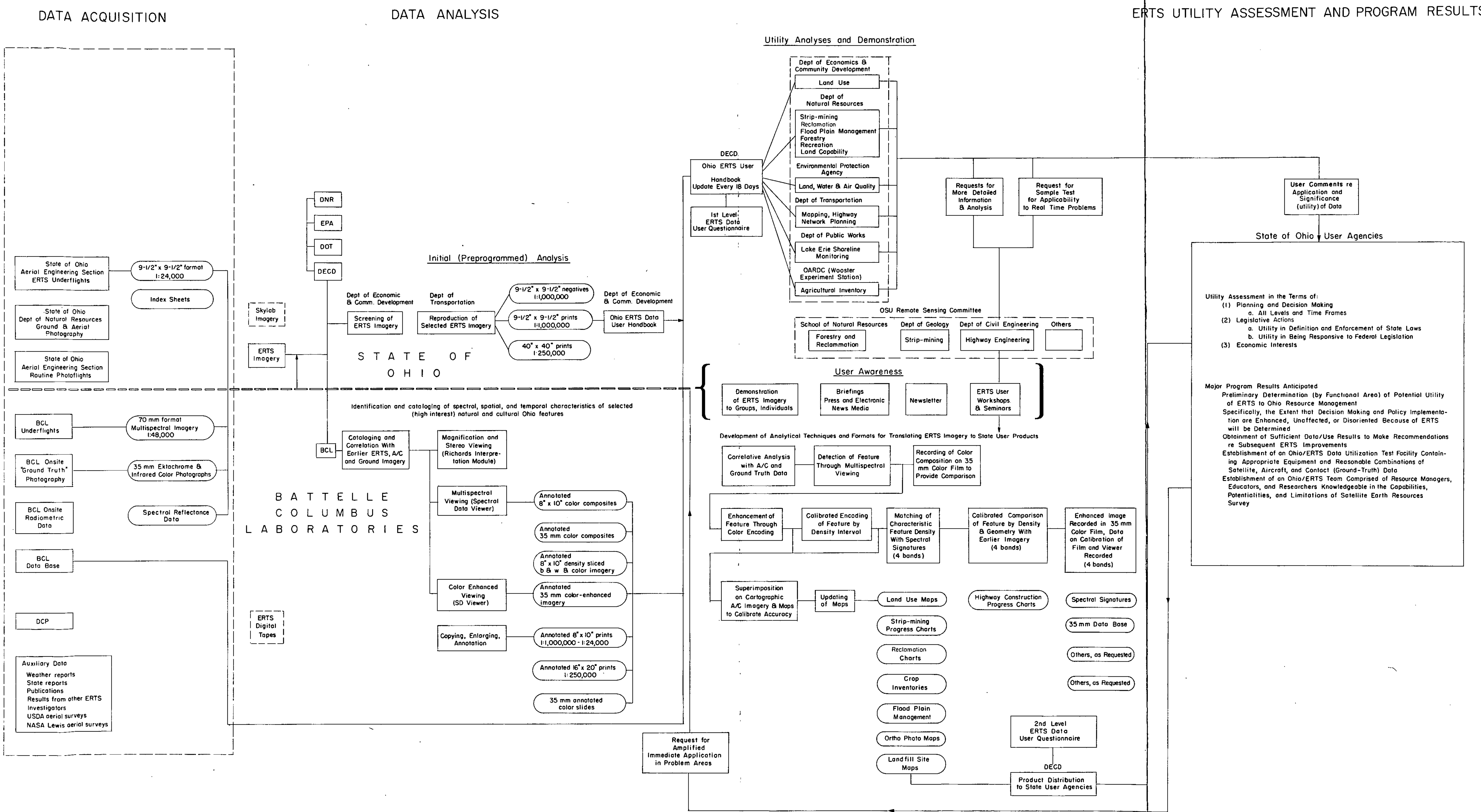

FIG. 2. ERTS DATA PROCESSING, ANALYSIS, AND EVALUATION PLAN

FOLDOUT FRAME 1

FOLDOUT FRAME 2

Following are sample analytical tasks wherein ERTS data utility was successfully examined. Details of the analytical techniques involved and results obtained will be contained in the project's final report.

(1) Application Area: Surface mining

Requester: Ohio Department of Natural Resources

Request: (a) Does ERTS imagery show the presence of strip mines, specifically those mined for coal?

(b) What is the smallest strip-mine feature, in area units, detectable with ERTS?

(c) How accurately can a strip-mine feature be located geographically?

(d) What is the largest scale to which ERTS imagery may be enlarged to be used in conjunction with USGS topographic map sheets:

1:1,000,000
1:500,000
1:250,000
1:24,000.

Analysis Results: Since most of the areas requested were were outside designated ERTS study sites, topographic map sheets and aerial photography were obtained from the Ohio Department of Transportation. By using the 1:24,000 scale photography and the USGS map sheets as reference, it could be determined that:

(a) Using the Color Additive Viewer, it was found that ERTS imagery reflects strip-mine features in Ohio very vividly in Band 5. The reflectance characteristics of bare soil and vegetation in east and southeast Ohio differ sharply in the visible band, making boundary definitions readily possible (see Ref. 1, Appendix)

(b) Using the Image Density Slicing Viewer and the Richardson Interpretation Module, it was found that areas as small as 2 to 3 acres of strip-mined areas were detectable. This required magnification in excess of 140X when viewing 70-mm film (scale, 1:3,300,000,000), and more than 30X when viewing the 9" x 9" ERTS imagery (scale, 1:1,000,000).

(c) When locating the presence of relatively large strip-mine features (areas 1 square mile and larger) it was possible to locate these and reference them to map scales up to 1:100,000. This meant that the ERTS imagery could be used by one of several techniques to update a map sheet without noticeable geographic distortions. It was found in virtually every case that existing Ohio maps displayed less strip-mined areas than could be observed in ERTS imagery.

The location of small strip-mined areas often presented a problem in that good reference points were often missing and that Ohio researchers needed to refer these small areas to a map scale of 1:24,000. To assist in the accurate location for the updating of 1:24,000 maps, an xy movement was added to the Spatial Data Image Density Slicing Viewer. By feeding the xy values into the servo drive, these small areas were located quickly and reference to the next prominent road intersection made. Though it has not been possible to approach the map accuracies of a Class A map at scale 1:24,000 (maximum allowable map error = 50 feet or .02 inch), most information sought is of a noncartographic nature, requiring relatively gross figures with an allowable map error 10X as high as sufficient.

Most significant was the finding that useful enlargements of ERTS data have been made up to scales as high as 1:20,000, a goal never initially thought achievable. However, a number of demonstrations have shown that the enlargement of strip-mine features using image enhancement techniques readily achieve such scales. It is conceivable that additional useful information will be detected in yet greater magnification. However, the present configuration of the facility's equipment and the current demand for data do not make investigations at larger scales desirable.

It should be pointed out that only infrequently does the requester ask for a cartographic product. In most cases, the request is for specialized area and/or feature data for decision making data which may be fitted with minor effort into existing cartographic and noncartographic products.

(2) Application Area: Strip-mine inventorying

Requester: Ohio Department of Natural Resources

Request: Can ERTS imagery be used for the gross inventories of unreclaimed strip-mine areas?

Analysis Results: Again the use of ERTS Band 5 was found to be most useful. Using the electronic planimeter capability of the Spatial Data Image Density Slicing Viewer, and standard planimetric techniques a test survey was made of Harrison County, eastern Ohio (see Reference 1 in the Appendix). The results showed that typical agreement between ERTS imagery, map sheets, and state figures in a county of 258,000 acres agreed to within 3 percent. According to State of Ohio figures, the lower figures obtained from ERTS imagery were more correct because the state counted the same strip-mine areas 2 to 3 times, even though it constituted the same areas.

(3) Application Area: Strip-mine reclamation monitoring

Requester: Ohio Department of Natural Resources and Ohio Geological Survey

Request: (a) To what detail is strip-mine reclamation discernible in ERTS imagery?

(b) Can an old strip-mine area under reclamation be detected?

(c) Can the degree of progress in an area of reclamation be determined?

Analysis Results:

(a) The strip-mine demonstration product directs itself to this question. Comparing aerial underflight panchromatic photography at a scale of 1:24,000 with ERTS imagery blown up to the same scale it was found that the examination of ERTS Bands 5 and 7 in some instances yield more information than the comparative aircraft photography. This was the case for at least two features: water and residual vegetation in the strip-mine area. The image density slicing viewer has been able to discern 25-30 density differences in a single strip-mine area which may eventually be relatable to spoil bank materials, high walls, and other features appearing in a typical Ohio strip mine.

(b) Older strip-mine areas under reclamation are best discerned on ERTS Band 7. They distinguish themselves by a less dense vegetation cover than the surrounding areas covered by original vegetation and by a large number of small ponds and lakes. Strip-mine areas 30 years and older have been observed.

(c) Since a strip-mine area is obvious by the removal of the so-called overburden or original vegetation, the restoration of such an area can be monitored by the increased recovering of such base areas. Analysis of areas under reclamation are made by comparing the area under reclamation with newly strip-mined land (0 percent reclamation) and original vegetation (100 percent). Degrees of reclamation are then made as 0-25 percent, 25-50 percent, 50-75 percent, and 75-100 percent.

(4) Application Area: All surface mining (gravel, lime, sandstone)

Requester: Ohio Department of Natural Resources

Request: To what extent can ERTS imagery be useful for detecting and distinguishing all surface-mining activities in Ohio?

Analysis Results: This request has been received relatively recent so that only 50 percent of the investigation has been completed. Gravel, lime, and sandstone pits are readily detectable using ERTS Band 5 imagery. Radiometric data acquired to date indicate that sufficient differences in reflectance characteristics exist to make distinction of the larger surface-mining operations possible.

(5) Application Area: Land use

Requester: Ohio Department of Economic and Community Development

Request: Is ERTS data suitable for Ohio land-use classification purposes, and, if so, to what level?

Analysis Results: Primary analysis was made from ERTS Bands 5 and 7. Since it was not the intent of the program to develop a classification scheme, a prominent scheme, developed and used by the U. S. Geological Survey was adopted. An outline of this classification scheme is shown in Table VI. The level to which each major classification has been evaluated thus far for Ohio-ERTS land-use tasks is shown on the right side of the table. The ability and plan to update land-use maps such as the land-use map published by the State of Ohio in 1967 is described in Reference 1 contained in the Appendix.

(6) Application Area: Environmental Quality

Requester: Ohio EPA

Request: (a) Can ERTS imagery be used to map the sediment patterns in the west and southern portions of Lake Erie and other major Ohio bodies of water?

(b) Can ERTS be used to determine the presence of Lake Erie algae?

TABLE VI. USGS LAND-USE CLASSIFICATION SYSTEM FOR USE WITH REMOTE SENSOR DATA*

Level I	Level II	ERTS, Analysis Status (Includes Levels 1 & 2)
01. Urban and Built-up Land.		
	01. Residential	TBD**
	02. Commercial and Services	TBD
	03. Industrial	TBD
	04. Extractive	Yes
	05. Transportation, Communications, and Utilities	Yes
	06. Institutional	TBD
	07. Strip and Clustered Settlement	Yes
	08. Mixed	Yes
	09. Open and Other	Yes
02. Agricultural Land		
	01. Cropland and Pasture	Yes
	02. Orchards, Groves, Bush Fruits, Vineyards, and Horticultural Areas	TBD
	03. Feeding Operations	TBD
	04. Other	TBD
03. Rangeland		
	01. Grass	N/A***
	02. Savannas (Palmetto Prairies)	N/A
	03. Chaparral	N/A
	04. Desert Shrub	N/A
04. Forest Land		
	01. Deciduous	TBD
	02. Evergreen (Coniferous and Other)	TBD
	03. Mixed	Yes
05. Water		
	01. Streams and Waterways	Yes
	02. Lakes	Yes
	03. Reservoirs	Yes
	04. Bays and Estuaries	Yes
	05. Other (Ice and Snow)	Yes
06. Nonforested Wetland		
	01. Vegetated	Yes
	02. Bare	Yes
07. Barren Land		
	01. Salt Flats	N/A
	02. Beaches	TBD
	03. Sand Other Than Beaches	TBD
	04. Bare Exposed Rock	TBD
	05. Other	TBD
08. Tundra	01. Tundra	N/A
09. Permanent Snow and Icefields	01. Permanent Snow and Icefields	N/A

* "A Land-Use Classification System for Use With Remote Sensor Data", J. R. Anderson, E. E. Hardy, & J. T. Roach, Geological Survey Circular, 671, Washington, D. C., 1972.

** TBD = To be determined by future analysis.

*** N/A = Classification not applicable to Ohio.

Analysis Results:

(a) ERTS Bands 5 and 7 were analyzed on the multispectral viewer and the density slicing viewer. It was found that ERTS imagery displayed a comprehensive/synoptic view of the Lake Erie pattern never before observed by EPA personnel, though aware of its existence. The sediment patterns as observed offshore in a triangle formed by Detroit, Toledo, and Cleveland could be discriminated into as many as 50 to 60 different levels using ERTS Band 5. Future research will determine if the high number of density levels can be tied to (a) sediment concentration per unit volume, and (b) type of suspended sediments. It was found, for example, that outfalls of the Cuyahoga River have displayed an uncharacteristic very dark color, which may be indicative of types of materials dumped into the river. (Most outfalls from industrial plants appear light.)(See Figs. 3-5)

(b) ERTS Band 7 of imagery taken by the satellite last August and September were analyzed with no apparent traces of algae on Lake Erie. According to EPA, the algae is only visible in July and early August around Kelly Island, so that future photography will have to provide more positive results.

(7) Application Area: Environmental quality

Requester: U. S. Army Corp. of Engineers

Request: Is ERTS imagery data suitable for determining the presence and location of offshore currents in the Maumee Bay (Toledo) area?

Analysis Results: The Corps. of Engineers required information regarding lake currents of the western bay area for a proposal for the building of levies in that area. Annotated information was made available for that purpose.

(8) Application Area: Forestry inventory

Requester: Ohio Department of Economic and Community Development and Ohio Department of Natural Resources

Request: (a) Is ERTS data suitable for inventorying forested areas?

(b) Can forest types be distinguished?

Analysis Results:

(a) When analyzing forested areas using ERTS Band 5, it was found that more than sufficient image detail could be derived for updating the 1960 Ohio land-use map of scales 1:500,000 and 1:250,000. In fact, some of the ERTS data proved to be more accurate. It was also found that forested areas could be very well delineated from Band 7 imagery taken over Ohio of snow-covered areas.

(b) Investigations are currently under way to determine if forest types may be distinguished.

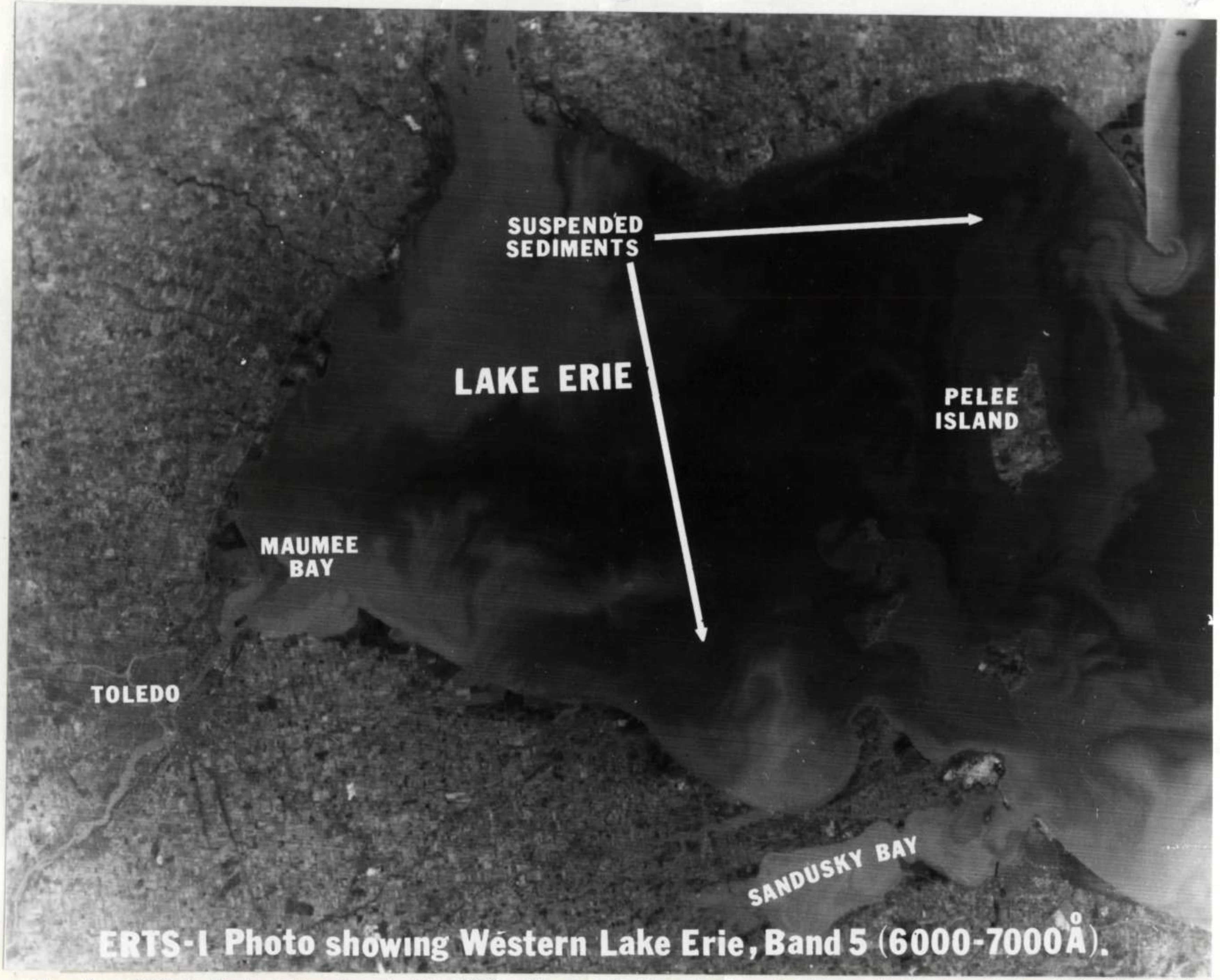

Fig. 3. ERTS-1 Photo Taken March 27, 1973, Showing Sedimentation Patterns in Western Lake Erie (Band 5, 6,000-7,000 Å). Note that the Sandusky Bay land areas appear partially inundated (See Figure 4 for comparison).

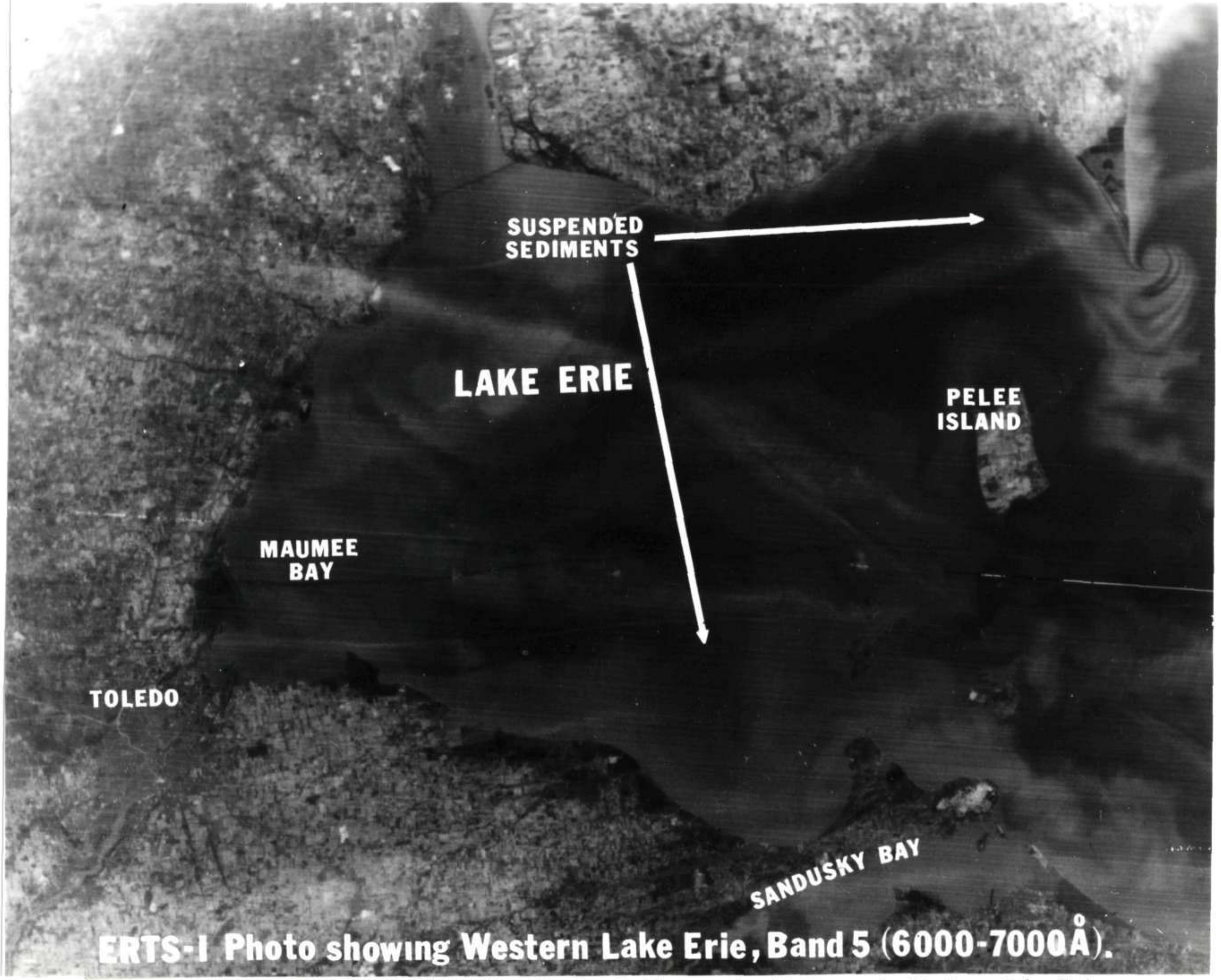

Fig. 4. ERTS-1 Photo Taken April 14, 1973, Showing Sedimentation Patterns in Western Lake Erie. Also note that waters in Sandusky Bay area have receded (see Fig. 3 for comparison).

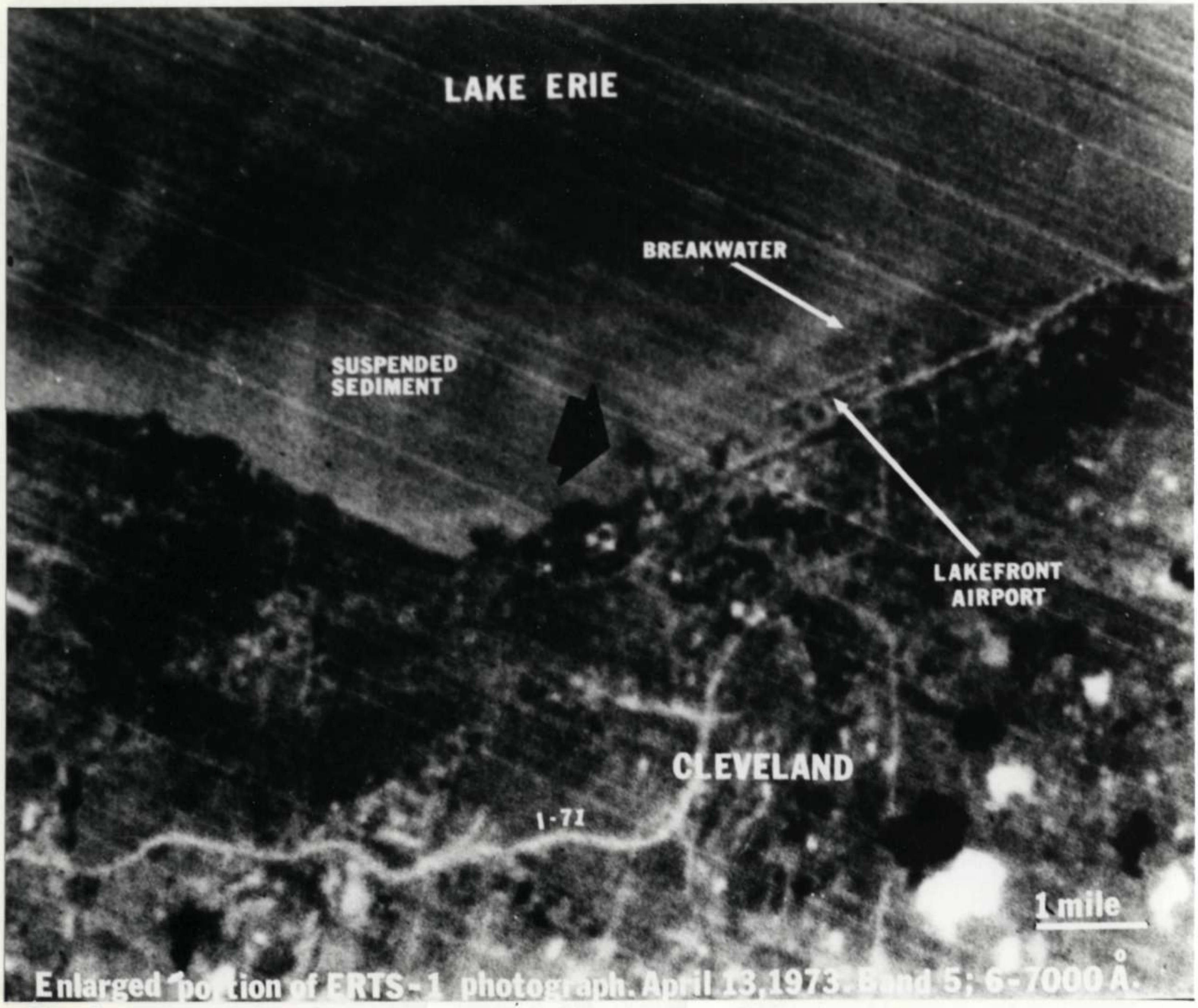

Fig. 5. Enlarged photograph of Lake Erie shoreline in the vicinity of Cleveland, Ohio. A very dark plume appears at the mouth of the Cuyahoga River (indicated by black arrow), indicative of possible pollutants in the river.

V. DATA UTILITY ASSESSMENT

During this reporting period (January-June, 1973), two specific products were prepared and distributed in accordance with the project's objective of obtaining an assessment of the utility of ERTS data to Ohio. The first was the manuscript entitled "Ohio-ERTS Data User Handbook", the cover letter and the table of contents of which are contained in the Appendix (Reference 2).

The handbook was designed to promote user awareness across a broad spectrum of state environmental and resource management decision making and/or problem solving functions and accordingly requires no specialized knowledge of either remote sensing or space technology on the part of the reader. The handbook is divided into four parts supplemented by several Appendixes. Part I contains a brief description of the NASA-ERTS program, the ERTS-1 spacecraft and sensors, and the Ohio-ERTS user investigator program. Part II identifies the ERTS-1 data and associated aircraft and ground-truth data available on Ohio, describes procedures being employed to analyze the data, and contains samples of the better quality ERTS-1 imagery on Ohio currently available. Part III describes plans and results of project activities concerned with demonstrating and/or assessing ERTS data utility, and Part IV describes miscellaneous project activities, including reports and releases prepared to date. A collection of reports, pamphlets, etc., are contained in Appendixes for those handbook recipients interested in more specific details. It is currently planned to periodically update thishandbook, particularly insofar as providing additional copies of usable ERTS-1 imagery acquired for Ohio.

The second item was a demonstration product summarizing how ERTS data can be utilized to detect and monitor the various types of surface-mining operations in Ohio. This item was attached to the project's Type II progress report for April/May, 1973.

As previously mentioned, the analyses of ERTS imagery to date have indicated three major areas in which state government in Ohio may benefit from ERTS and future orbital surveys--land use, strip-mine monitoring, and Lake Erie water quality work.

A preliminary estimate of the land-use mapping capability during this reporting period indicates that ERTS imagery can be useful in mapping general state land use at a scale of 1:250,000 and perhaps in some cases at 1:125,000. This type of mapping will be useful to the state in overall long-range, land-use planning and in meeting the requirements of the pending National Land-Use Policy Act. Ohio has previously constructed a map at the scale of 1:250,000 for the entire state at a cost of somewhat over $250,000. ERTS photography provides an opportunity to update statewide land-use mapping at a significantly smaller cost. We estimate that the state could be mapped using ERTS imagery at a cost of from $40,000 - $50,000. In addition to cost savings, the ERTS photography would represent an improvement in terms of time span. ERTS photography to map the entire state has become available in less than a year. In the 1960 land-use study aerial photography over a period from 1958 to 1964 was generalized. Of course, aerial photography for the entire state could have been flown during a shorter time span but this would have been much more costly than making maximum use of available photography.

This is not to say that there aren't some trade-offs involved in obtaining this low-cost, land-use mapping. The 1960 study was done at a scale of 1:24,000 and then combined and generalized to arrive at the 1:250,000 and 1:500,000 maps. Thus, detailed land-use work sheets were available as back-ups and for use by planners who needed detailed information. Using the ERTS photography this won't be possible except for certain limited kinds of features in selected areas of the state. Perhaps an operational satellite should be put into a slightly lower orbit and contain both general ERTS-type sensors and special high-resolution sensors to be turned on selectively during periods of low cloud cover over areas where users need high-resolution data.

The second area which ERTS promises benefit to the state is in strip-mine monitoring and reclamation. During the last reporting period, the capability of ERTS photography to identify reclaimed areas as well as unreclaimed strip mines has been established. This confirms the fact that ERTS can be useful in monitoring reclamation progress. It is felt that with the use of tapes, as other investigators from Ohio are doing, this process can be refined to be even more useful in terms of related environmental quality/ecological implementations.

The capability of ERTS photography to discern varying states of reclamation will also be useful to a new state agency, the Unreclaimed Lands Board. This board was set up to make use of severance tax and penalty money to reclaim lands which were strip mined before strip-mine laws were enacted and during the period of time during which Ohio had a minimal strip-mine law. The board is at the preliminary point where they must set priorities. Many old strip mines have been reclaimed naturally to some extent. The board needs an inventory of the distribution and condition of old strip mines. They plan to ask for proposals from several contractors to do this using ERTS photography.

The capability of ERTS to detect areas mined many years ago has also been used by the Ohio Geological Survey in a project they are doing to determine how much of certain coal seams remain to be mined. In this case rather than a time-consuming search of old permit records, ERTS photography was used to determine if certain suspected areas had been strip mined many years ago.

Staff members from the Ohio EPA have recently become very interested in possible uses of ERTS photography in Lake Erie pollution and sedimentation studies. It appears that ERTS imagery may give a clue to some of their problem areas such as a better definition of nearshore versus offshore environment in terms of pollution and sedimentation. Other application areas which the OEPA is interested in evaluating include: littoral drift/lake dispersions, algae masses, temperature phenomena, water level (for coastal zone management also an interest of the Department of Natural Resources), and wave refraction. Realizing that these areas cannot be treated in great depth under the present ERTS contract, the Ohio EPA is working jointly with The Ohio State University-Center for Lake Erie research and the Battelle Columbus Laboratories in developing a proposal to the Federal EPA for greater data collection and in-depth ERTS imagery analysis on Lake Erie.

VI. SIGNIFICANT RESULTS

During the first six months of project effort the ability of ERTS imagery to be used for mapping and inventorying strip-mined areas in southeastern Ohio was reported as a significant project result. During this reporting period, the potential of using ERTS imagery in water quality and coastal zone management of Lake Erie became apparent and the extent that ERTS imagery could contribute to localized (metropolitan/urban), multicounty, and overall state land-use needs was experimentally demonstrated.

VII. MISCELLANEOUS

During the last six months, efforts aimed at improving the user and public awareness of the ERTS program continued. These efforts included setting up and conducting numerous tour/visitations to the ERTS analysis laboratory at Battelle, preparing ERTS displays for participating state agencies, and issuing news releases. Nearly 200 more visitors from industry, governmental agencies, and educational institutions have visited the laboratory during the last six months making a total of over 300 visitors to date. At the request of the Remote Sensing Committee of The Ohio State University, a graduate-level seminar on the analysis and multidisciplinary applications of ERTS data was conducted by the Ohio-ERTS project staff on April 24, 1973. This seminar at The Ohio State University was followed by a two-hour, in-the-laboratory seminar at Battelle's ERTS analysis laboratory for 25 students on May 21, 1973. On June 14, 1973, the Professional Land Surveyors of Central Ohio had their monthly meeting at Battelle's ERTS analysis laboratory at which time the Ohio-ERTS project was reviewed and a laboratory demonstration provided. On May 16, 1973, the Battelle Remote Sensing Applications Laboratory and the multidisciplinary Ohio-ERTS/Skylab programs were the subject of an electronic news conference which resulted in a four-minute special feature during the local CBS TV evening news broadcast. Likewise, William McCann, a Cleveland newspaper feature writer, interviewed both State and Battelle personnel in connection with a forthcoming article he is preparing on Ohio-ERTS. ERTS imagery display boards were recently constructed and distributed to the various state agencies participating in the Ohio-ERTS program. These display boards contain 40" x 40" enlargements of ERTS imagery on Ohio, assorted annotated enlargements, and color composite samples. Also, numerous other ERTS demonstration products have been made at the request of various governmental agencies.

In an effort to inform the Office of Management and Budget of Ohio's interest in satellite survey opportunities and concern regarding recent ERTS/ Skylab funding decisions, a letter was prepared by Governor John J. Gilligan of Ohio, and was sent to Director Roy Ash of the Office of Management and Budget. A copy of this letter is attached to this report as Reference 3 in the Appendix Also, we have responded favorably to participating in the Department of Interior's ERTS Cost-Benefit Study being conducted by the Earth Satellite Corporation.

Mr. George Wukelic and Mr. Joachim Stephan of BCL and Mr. Terry Wells of the State of Ohio attended the ERTS-1 Symposium held by NASA at the Sheraton Motor Inn in New Carrollton, Maryland, on March 5-9. Mr. Wukelic presented the paper entitled "Resource Management Implications of ERTS-1 Data to Ohio", by David C. Sweet, Terry L. Wells, and George E. Wukelic. A copy of this paper is attached as Reference 1 in the Appendix to this report.

During the next six months, we plan to present a paper on the Ohio-ERTS effort at the symposium on "Management and Utilization of Remote Sensing Data", sponsored by the American Society of Photogrammetry at the EROS Program Data Center on October 29-November 2, 1973. In addition, an Ohio-ERTS program exhibit is being prepared for the 1973 Ohio State Fair.

APPENDIX

RESOURCE MANAGEMENT IMPLICATIONS OF ERTS-1 DATA TO OHIO

by

David C. Sweet and Terry L. Wells
State of Ohio -- Department of Economic and Community Development

and

George E. Wukelic
Battelle Columbus Laboratories

Paper Presented at

SYMPOSIUM ON SIGNIFICANT RESULTS OBTAINED FROM ERTS-1
New Carrollton, Maryland
March 5-9, 1973

RESOURCE MANAGEMENT IMPLICATIONS OF ERTS-1 DATA TO OHIO

David C. Sweet and Terry L. Wells
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ABSTRACT

Initial experimental analysis of ERTS-1 imagery has demonstrated that remote sensing from space is a means of delineating and inventorying Ohio's strip-mined areas, detecting power-plant smoke plumes, and providing the data necessary for periodically compiling land-use maps for the entire state. This paper summarizes the nature and extent of these problems throughout Ohio, illustrates how ERTS data can contribute to their solution, and estimates the long-term significance of these initial findings to overall resource management interests in Ohio.

1. INTRODUCTION

NASA has provided the State Government of Ohio, on behalf of a number of its agencies* and assisted by Battelle Memorial Institute's Columbus Laboratories, with the opportunity to participate in the ERTS-1 program as a multidisciplinary user-investigator concerned with evaluating the state resource management implications of ERTS-1 data. This symposium has been organized to publicize significant results thus far obtained from ERTS-1. In this connection I would like to report first on what we feel is our most significant result to date. This is the swiftness with which remote sensing from space has captured the interest and confidence of potential state and local user groups, in spite of their limited previous experience in applying remote sensing technology. Moreover, significant progress toward demonstrating state-level utility has occurred. However, state needs for larger scale imagery and thermal infrared data for many applications are much in evidence. While in many cases our application findings and potential benefits are not directly translatable to other states, we nonetheless feel confident that the promise of ERTS will spread throughout the nation, insuring adequate user support for continuing orbital survey missions.

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* Department of Economic and Community Development (Lead Agency)
Department of Natural Resources
Department of Transportation
Ohio Environmental Protection Agency

2. PRELIMINARY RESULTS

Although clouds have been a continuing problem, usable ERTS MSS imagery has been acquired for almost the entire state. However, the current availability of usable repetitive data is limited to portions of eastern Ohio. For imagery analysis and interpretation we are utilizing manual electro-optical image analysis techniques (multispectral and density/color viewers). These have been equally effective in visually demonstrating ERTS potentialities, accommodating real-time problem solving exercises involving technical and planning specialists, and generating sample ERTS data application products for subsequent utility assessment. The status of and state interest in our analytical program efforts are briefly summarized in Table I. Further discussion is limited to areas wherein ERTS data utility has definitely been demonstrated.

TABLE I. STATUS OF MAJOR ERTS DATA APPLICATION CANDIDATES UNDER EXAMINATION IN OHIO

Application Area	State Need	Potential State Value
	Utility Feasibility Demonstrated	
Strip mining	> 1/4 million acres affected	Help implement 1972 strip-mine law
Land use	Multiagency priority problem	Provide periodic statewide views of major land-use changes
Air quality	New Ohio EPA interest	Test computer model
Mapping	Current maps needed at all agency levels	Prepare photo base maps
	Utility Feasibility Under Study	
Sanitary land fills	> 1,400 illegal sites estimated	Detect illegal and/or new sites
Flood plains	50 % of Ohio cities subject to flood damage	Help define and enforce statewide regulatory law
Outdoor recreation	50 state parks exist--major expansion program underway	Help select new sites
Lake Erie	Unusual high water level posing severe erosion and flood hazard problems	Support Operation Foresight

A. Strip-Mine Reclamation Planning and Monitoring Implications

In April 1972, responding to overwhelming public sentiment, the Ohio Legislature passed legislation placing very stringent controls on strip mining in the state. This law places many new reclamation requirements on the operator, requires extensive preplanning of strip-mine operations, and gives the state the power to deny licenses to strip mine under certain conditions. The implementation of this law is a tremendous task which as yet hasn't been totally effected.

The state anticipates that ERTS data will prove useful in several ways in implementing the law. Initially, there is a need for an inventory and map of all strip-mined land to support reclamation planning activities, as an accurate and recent inventory in a readily available form does not exist. Information is especially scanty on land stripped before 1948, when Ohio passed its first strip-mine legislation.

As can be seen in Figure 1, ERTS photography is quite responsive to detecting surface-mining operations and reclamation efforts. This ERTS-1 scene of southeastern Ohio taken on August 21, 1972, shows an 8-mile long strip-mined area in which the Big Muskie is operating. Ground truth confirms that the dark square in the center of the stripped area was the location of the Big Muskie at the time. Figure 2 illustrates how well ERTS strip-mine imagery compares with aircraft photography. This photo shows a very small strip-mined area near Zaleski, Ohio. The satellite imagery has been magnified over 140 times to match the 1:24,000 scale routinely used in planning and map preparation.

With the ability to identify strip-mined areas established, an attempt was made to inventory and map the strip-mined areas of one Ohio county. Figures 3 and 4 show the distribution of stripped and unreclaimed land for Harrison County as displayed in an 32-color viewer enlargement of ERTS-1 MSS band 5 imagery. Area calculations correspond quite favorably to Department of Natural Resources (DNR) data. ERTS-1 data showed a total stripped acreage of 18.4 percent (or 47,472 acres) as compared to 19.01 percent (or 49,064 acres) for DNR. For unreclaimed acreage the figures were 6.2 percent for ERTS-1 and 6.8 percent for DNR. Comparison with aircraft data and on-site visitations are planned to further substantiate the accuracy of the inventory before proceeding with a 23 county survey of strip-mined areas in southeastern Ohio.

The current effort is to determine the extent to which ERTS multidate data can aid in enforcing the reclamation provisions of the strip-mine law. Under the law a strip-mine operator is required to commence backfilling, grading, and resoiling within three months after removal of overburden. Planting of vegetation must take place no later than the next appropriate season. With present ERTS resolution capabilities, it is doubtful that backfilling efforts can be monitored to the extent

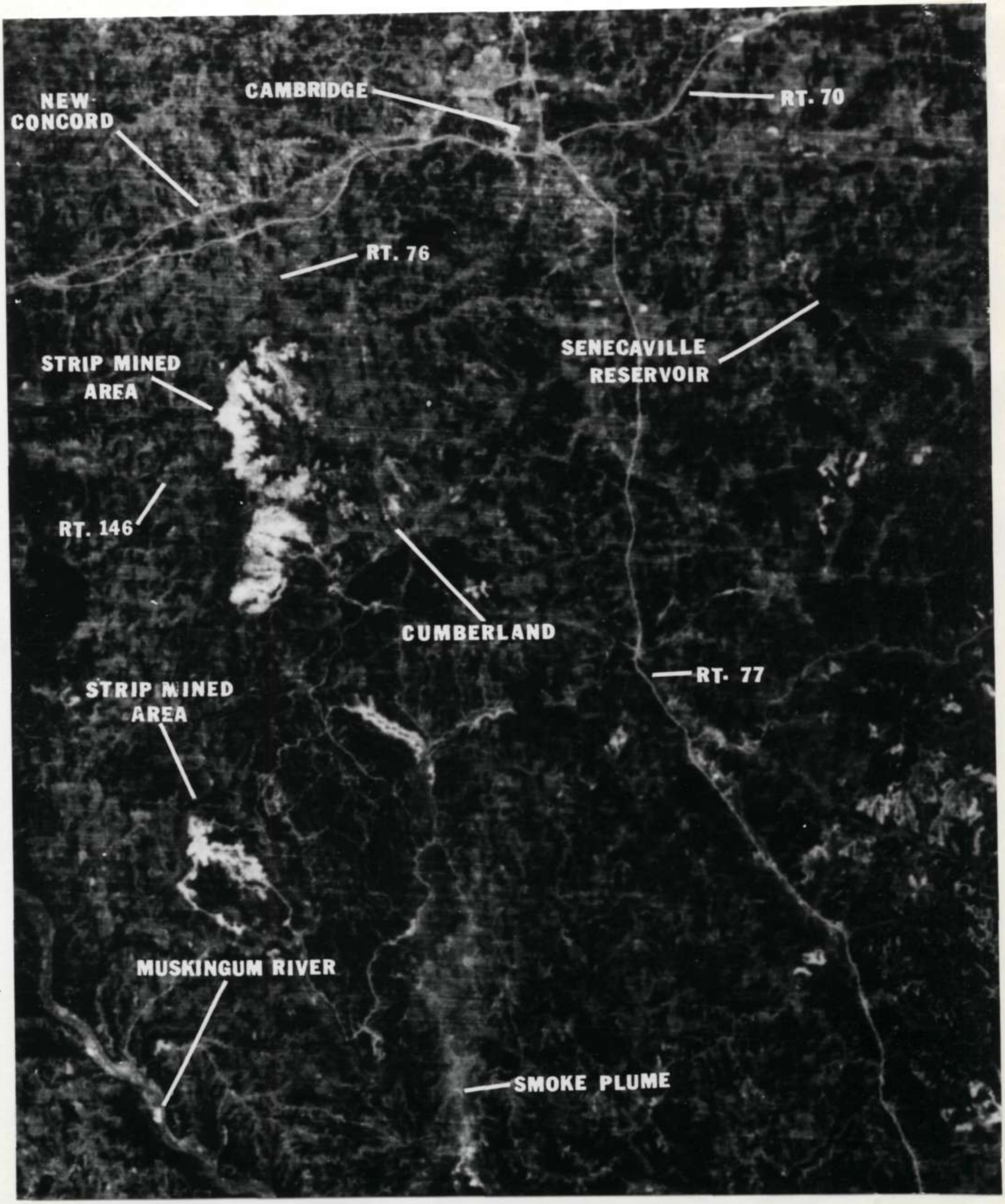

Fig. 1. Enlargement of ERTS MSS Band 5 Imagery (21 Aug 72) Showing Ohio Strip-Mine Areas.

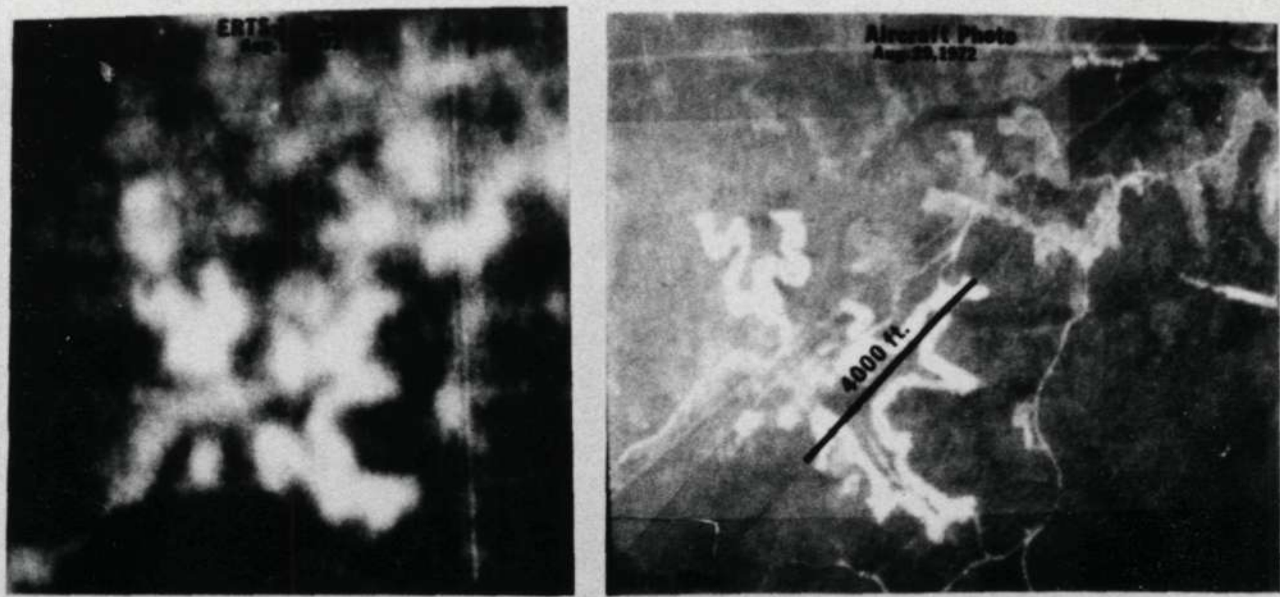

Figure 2. Comparison of ERTS-1 and Aircraft Photos of Strip-Mine Area Near Zaleski, Ohio. (Comparison Made at a Scale of 1:24,000.)

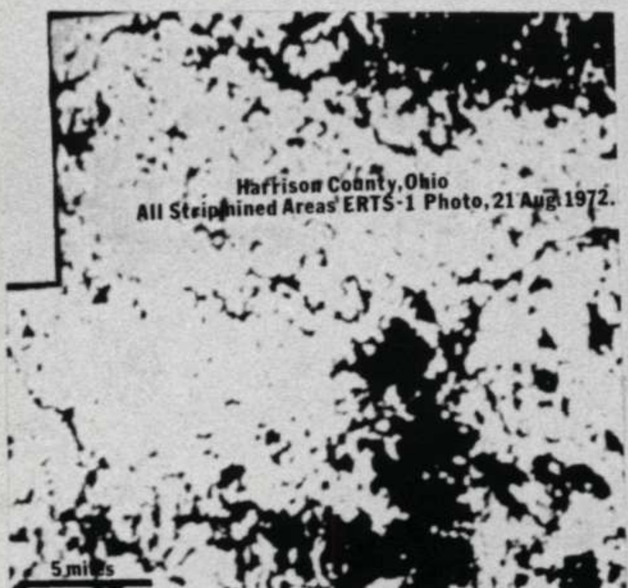

Fig. 3. Black Areas Represent Total Strip-Mined Areas of Harrison County, Ohio. (ERTS Imagery as Displayed on 32-Color Viewer.)

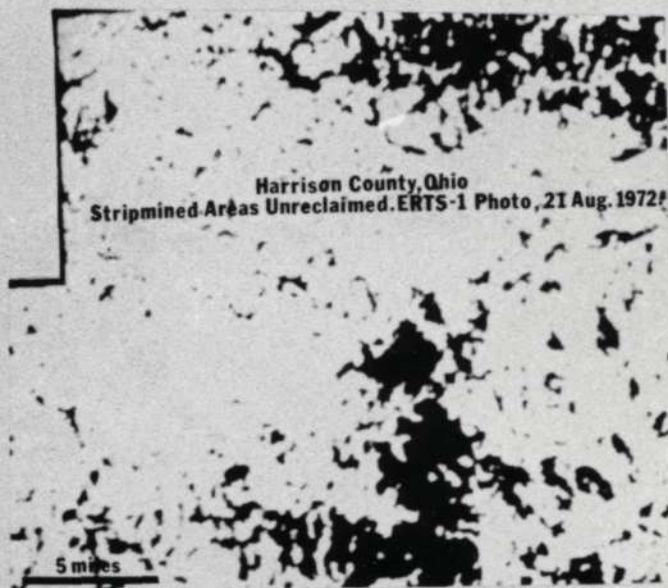

Fig. 4. Black Areas Represent Unreclaimed Strip-Mine Areas of Harrison County, Ohio. (ERTS Imagery as Displayed on 32-Color Viewer.)

necessary for regulatory purposes. However, ERTS data will be useful in determining if lasting reclamation has been accomplished. In many cases the initial vegetative cover appears healthy at first, but after several years a change in hydrologic conditions may cause acid water to reappear and destroy the vegetation. This capability will permit more accurate judgments in issuing permits and releasing bonds posted by strip-mine operators.

B. State Land-Use Planning Implications

Support for a national land-use policy has grown steadily stronger and indications are that Congress will soon act on one of the several land-use bills presently under consideration. One of the common features of these bills is that states will be required as part of their land-use planning process to include "the preparation and continuing revision of a statewide inventory of the land and natural resources of the State". This is one area in which orbital survey data will help multiagency efforts in Ohio. Specifically, ERTS imagery will provide a current and comprehensive data base illustrating the inter-relationships of static and dynamic natural and cultural surface features.

Thus far we have established that mapping of natural and cultural features from ERTS imagery can be done with confidence to scales of larger than 1:125,000. Figure 5 provides examples of our pilot land-use mapping efforts in the over 500 square mile Columbus/Franklin County area. These scenes, taken from the Spatial Data 32-color viewer, show the various major land-use features discernible: total urban coverage, urban growth that has occurred principally over the last 12 years, and distribution of tree stands, parks, and woods. Aerial photo index sheets have been found quite valuable in verifying the extent and geometry of the land-use patterns generated.

Our current objective is to attempt to update the general 1:500,000 scale land-use map of Ohio which was completed in 1967 at a cost of approximately a quarter million dollars. If successful, at least for USGS recommended Level I land-use categories, state planners will have a relatively inexpensive and periodic information base for making general land-use decisions. This information will not replace the need for more detailed studies in specific areas; and therefore, any improvement of resolution in future satellite survey missions will increase the value of the information provided.

C. Environmental Quality Implications

An Ohio Environmental Protection Agency was established in October 1972 to consolidate environmental quality protection activities in Ohio. It has prepared the implementation plan required by the Federal Clean Air Act to meet standards set by the Federal EPA. As part of this plan,

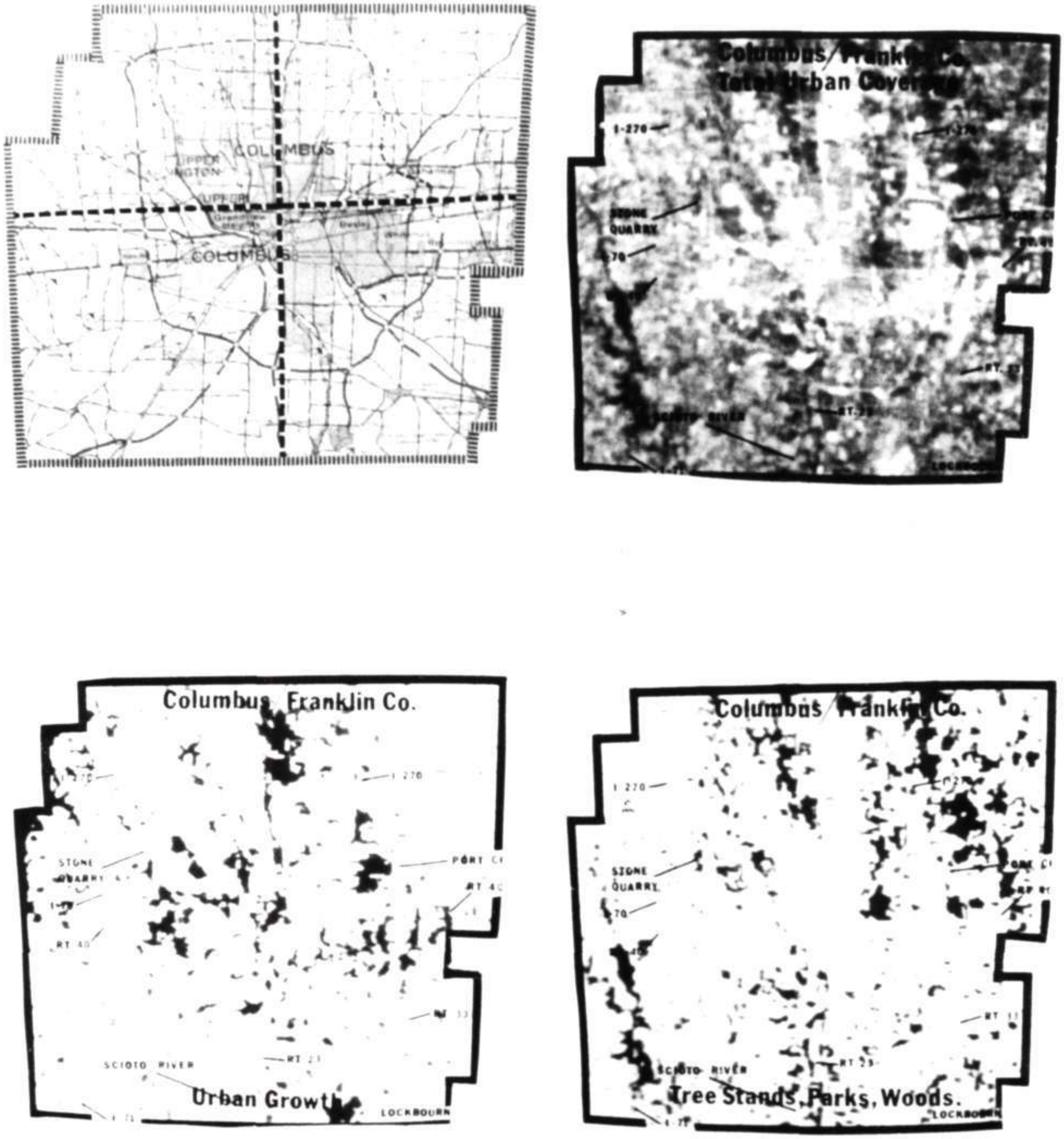

Figure 5. Illustrations of Urbanized Land-Use Features Discernible on ERTS-1 Photography.

officials are required to establish emission limitations for all significant state pollution sources. In an effort to determine the effect of pollution sources on air quality, the state has developed an air movement model. The demonstrated ability of ERTS to detect major smoke plumes on a repetitive basis will be utilized in combination with meteorological data to evaluate and verify this model. ERTS imagey may also reveal the extent to which smoke plume confluence is occurring.

Although the prime interests of state EPA personnel generally associate with thermal infrared data (unfortunately unavailable from ERTS-1), some preliminary assessments have been made as to the utility of ERTS for detecting illegal and/or selecting new sanitary landfill sites and monitoring Lake Erie sedimentation. Ohio EPA interest and confidence in applying remote sensing technology are manifest in a grant request submitted to enable the agency to purchase and operate a fully equipped remote sensing aircraft.

D. Mapping Implications

Enlargements of bulk processed ERTS MSS imagery have been found to match very closely most standard map scales in common use in Ohio. The resource management implications from the standpoint of preparing up-to-date thematic maps are obvious. Currently, 1:250,000 mosaics of Ohio in two MSS bands (5 and 7) are being prepared by the Department of Transportation. These mosaics will serve as photo base maps for state transportation research and planning.

3. SUMMARY AND RECOMMENDATIONS

Obviously, Ohio is optimistic about the resource management application opportunities emerging from initial ERTS imagery analysis. Hopefully, several demonstrated applications will mature into routine statewide planning functions, and additional application possibilities will surface. The economic and operational implications of these early results remain to be determined. Equally important is that some user enthusiasm is being lost because of the unavailability of thermal infrared data. Also, many application candidates proposed by state user agencies but found to be marginal or inappropriate based on current ERTS data capabilities, could become feasible were higher resolution imagery provided. Accordingly, from a state viewpoint, NASA's recent decision to incorporate a thermal infrared capability in the ERTS-B mission is sound and we suggest also that serious consideration be given to modifying the mostly redundant RBV into a system for providing larger scale imagery on a repetitive but longer term basis.

OHIO DEPARTMENT OF ECONOMIC AND COMMUNITY DEVELOPMENT
65 South Front Street / Columbus, Ohio 43215 / (614) 469-2480

JOHN J. GILLIGAN
Governor
DAVID C. SWEET
Director

May 2, 1973

The Department of Economic and Community Development is quite pleased with the results thus far in our NASA Earth Resources Technology Satellite (ERTS) program. We appreciate the assistance and cooperation which you have given us in this program. In keeping with our continuing effort to ensure a successful multidisciplinary, multiagency effort, I am enclosing a copy of our Ohio-ERTS Data USER Handbook. This book contains information on the ERTS satellite program, ERTS imagery of Ohio, and some interpretations of selected images. From time to time we will be sending you additions to this handbook as new imagery becomes available and additional interpretations are made.

We hope that this handbook will serve two major purposes. One is to provide you and your fellow workers with a readily available and up-to-date source book of ERTS data for Ohio, and the other is to help solicit feedback in the determination of potential uses and usefulness of ERTS data in Ohio State government activities. Specifically, it is our intention to follow this handbook with a questionnaire to solicit your views as to data needs and ways in which ERTS data may benefit you.

If you should have any questions or comments on the handbook, please call Terry Wells at 469-6954.

Thank you for your cooperation in the ERTS program.

Sincerely,

David C. Sweet

DAVID C. SWEET
Director

OHIO-ERTS DATA USER HANDBOOK

1973

PREPARED IN ASSOCIATION WITH THE OHIO-ERTS DATA USER PROGRAM -- NASA CONTRACT NAS-5-21782

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STATE OF OHIO
OFFICE OF THE GOVERNOR
COLUMBUS 43215

JOHN J. GILLIGAN
GOVERNOR

April 9, 1973

Mr. Roy Ash, Director
Office of Management and Budget
Executive Office Building
Washington, D.C. 20503

Dear Mr. Ash:

It has long been hoped that the results of space endeavors would become more directly useful to problem-solving in the public sector. Although several of NASA's application programs (viz., communications and meteorological satellites) have accomplished some such benefits, NASA's Earth Resources Technology Satellite (ERTS) program represents the first major opportunity for this hope to be realized at the state and local government levels.

Initial evaluations of multi-agency relevance of ERTS-1 data to resource management interests in Ohio under the leadership of Dr. David Sweet, Director, Department of Economic and Community Development, are quite promising. Specifically, we anticipate real benefits to be obtainable from even the experimental data currently being acquired to such priority Ohio planning and regulatory activities as strip mine inventorying and reclamation monitoring, environmental quality protection, and state-wide land use planning. Accordingly, we are concerned about recent funding decisions adversely affecting NASA's space applications programs, particularly those involving ERTS and Skylab (EREP) programs. We feel that further consideration should be given to ensuring that sufficient funds are provided to support continuing and viable programs in this area.

We in Ohio hope that our experience will help in shaping an OMB funding rationale which will enhance technology transfer and utilization in state and local government program operations.

Sincerely,

JOHN J. GILLIGAN
Governor

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JJG/TLW/jh